EXHAUST SYSTEM FLANGES

REFERENCE TO RELATED APPLICATION

This is a continuation-in-part application based on and claiming the benefit of United States patent application 09/758,311, filed January 12, 2001, which claims priority from United States provisional patent application no. 60/176,043, filed January 14, 2000 and United States provisional patent application no. 60/194,765, filed April 3, 2000.

FIELD OF THE INVENTION

[0001] This invention relates generally to exhaust systems and more particularly mainly to an exhaust flange assembly used in exhaust systems of internal combustion engines, such as those used in automobiles and trucks.

BACKGROUND OF THE INVENTION

[0002] In the field of exhaust systems, exhaust flanges are generally used to connect the ends of exhaust pipes to each other. In such systems, it is common to have stamped or forged and/or machined flanges which are welded to the ends of exhaust pipes which are to be joined to each other, with the flanges having flat mating surfaces which are bolted together with a gasket in between. However, there are various disadvantages of prior art exhaust flanges when the two flanges are mated.

[0003] Firstly, some prior art exhaust flanges are manufactured by a stamping process along with a machining process. However, this is quite an expensive overall process to use and maintain and requires lots of machinery and manpower to operate. Also, the use of stamping and machining does not allow for complex shapes to be manufactured at an economically feasible rate.

[0004] Another disadvantage of prior art flanges is that they are susceptible to leaks. When the flanges are mated, there generally exists small holes or paths whereby exhaust escapes out of the exhaust system and is released into the atmosphere. Furthermore, some of the leaks which appear in existing exhaust flanges are caused by flanges which are

misaligned with each other such that when the flanges are mated, the faces of the flanges do not lie flat against each other. Another factor which causes the misalignment of exhaust flanges is that fastening means, in the form of studs or bolts, are not formed integral to the flanges. Instead, the studs are usually separate parts which may affect the alignment of the two flanges. Also, the studs may slip after being fastened causing the flanges to be further misaligned. Furthermore, in some prior art flanges, over-tightening of the fastening means causes the flanges to deflect away from each other thus causing leakage.

[0005] Existing exhaust flanges are also quite heavy which may affect the overall exhaust system since the heavier flanges require more support when installed. In some prior art exhaust flanges assemblies, the assemblies include gaskets which assist in the sealing process. However, some suffer from having these gaskets fall out during assembly of the system causing the system to either fail or stopped.

[0006] It is therefore, desirable to provide a novel exhaust flange assembly.

SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to obviate or mitigate at least one disadvantage of previous exhaust system flanges.

[0008] In one aspect of the invention, instead of manufacturing flanges by stamping, forging and/or machining, the flanges are formed by powder metallurgy, which offers a number of advantages, including the ability to achieve flange shapes which cannot be obtained by stamping. Furthermore, the powder metallurgy process also is more economically feasible than some prior art flange manufacturing processes.

[0009] In accordance with one aspect of an exhaust flange assembly, there are two flanges, one on the end of a first exhaust pipe and one on the end of a second exhaust pipe. The flanges have complementary shapes, such that one of the flanges, which may be seen as an "inner flange", nests partially within the other flange, which may be seen as an "outer flange".

[0010] In another aspect of the invention, one of the flanges, preferably the inner flange, has integral mounting studs on opposing sides of the exhaust pipe, configured to extend through corresponding holes in the outer flange. The studs are threaded to receive nuts which are tightened to draw the two flanges together for a secure connection when the

flanges are mated. Furthermore, material may be added to the flanges in predetermined areas so as to reduce or eliminate the amount of deflection when the flanges are mated.

[0011] Preferably, the proximal surfaces of the flanges, i.e. the surfaces of the flanges away from their mating surfaces, comprise reinforcement ribs, which allow the overall thickness and weight of the flanges to be reduced compared to conventional flanges. As an alternative to reinforcement ribs to reduce weight, the flanges may comprises through holes formed in several locations to achieve similar weight reduction.

[0012] In a further aspect of the invention, the flanges have extensions for attachment by press-fitting, spinning, resistance welding, crimp rolling or other known processes to the exhaust pipes. Thus, no welding is necessary between the exhaust pipe and the extension other than as a further reinforcement of the joint.

[0013] Furthermore, the nesting together of the flanges provides an improved seal between the flanges, in that there is little or no escape route for exhaust gases, thus reducing the need for expensive gaskets to be placed between the flanges or perhaps eliminating the need for gaskets altogether. Also, the use of powder metallurgy allows for larger diametered studs and matching holes with close tolerances to be manufactured to form a rigid exhaust flange assembly. There may also be composite material inserted between the mating faces of the two flanges to provide further sealing properties to the exhaust flange assembly.

[0014] Another advantage of the invention is that since the mounting studs or bolts may be integral to the flanges, the exhaust flange assembly will tend to remain intact even if the nuts become loose or dislodged from the studs unlike prior art flanges whereby if the bolts fall out the connection between the two flanges shifts. One other advantage is that the nesting of one flange within the other reduces the lateral shifting of the exhaust flange assembly, even if the nuts are loose or missing, causing the exhaust flange assembly, or flange joint, to be mechanically secure.

[0015] Moreover, at least one of the flanges has an annular gasket recess located on its sealing surface. The annular gasket recess preferably has gasket retaining means, either gasket recess protrusions or the gasket recess being generally oval, for retaining the gasket by bending the substantially circular gasket to an oval shape inside the gasket recess.

[0016] In another aspect, the outer flange and the inner flange have stud mounting holes arranged to receive threaded studs onto which nuts are threadable, whereby the flanges may be drawn together for a secure connection by the nuts.

[0017] In yet another aspect of the invention, the outer flange has a curved extension protruding in a direction opposite to the cavity defined in its sealing surface, and the inner flange has a curved extension protruding in a direction opposite to its sealing surface, the extensions arranged to be fitted into the ends of exhaust pipes. Preferably, the end of the exhaust pipe is press-fitted, spun, resistance welded, crimp rolled or roll-formed to conform to the outer surface of the extensions which has a groove surrounded by an inner ridge and an outer ridge.

[0018] In another aspect, the studs, and or bolts, have generally spherical portions facing the bolt thread, the spherical portions of the bolts arranged to cooperate with generally concave recesses arranged in the flanges around mounting holes. The studs may also include hexagonal portions which prevent the stud from spinning after the flanges have been mated.

[0019] Still a further embodiment of an exhaust flange assembly, according to an aspect of the invention, comprises a straight flange cooperating with a curved flange, where an outer edge of the curved flange is bent away from the surface of the curved flange which contacts the straight flange, so that, when the straight flange is mated to the curved flange by fastening means, the curved flange deflects towards the straight flange to form a flat sealing surface, thus enhancing the seal between the curved flange and the straight flange. The curved flange is substantially weakly bowl-shaped Preferably, the straight flange and the curved flange have mounting holes and the fastening means comprise mounting studs, for placement through the mounting holes, and mounting nuts to be tightened onto each mounting stud, for drawing the straight flange and the curved flange together. In another aspect of the invention, the straight and the curved flanges have gasket recesses, for accommodating gaskets.

[0020] In a further aspect, the exhaust flange assembly has an inner flange comprising a shaped recess for receiving one side of a gasket and an outer flange comprising a cavity for receiving another side of the gasket element. When the flanges are mated, the gasket rests in between the mating surfaces of the two flanges thereby providing improved sealing characteristics for the exhaust flange assembly.

[0021] An elongated substantially flat exhaust flange, according to a further aspect of the invention, comprises a sealing surface having a cavity and a pipe attachment means, seen as an extension, arranged on a surface opposite the sealing surface.

[0022] In another aspect of the invention, there is provided a method of producing exhaust flanges comprising the steps of press-forming metal powder to shape a first substantially flat part of an inner flange; press-forming metal powder to shape a second annular sealing part of the inner flange; fitting the first part onto the second part; and sintering the first part and the second part to thereby bond them together and form the inner flange.

[0023] Advantageously, the method further comprises the step of pre-sintering the first part and the second part after press-forming but before fitting the first part onto the second part.

[0024] Preferably a weld is applied to a joint between the first part and the second part after the first part is fitted into the second part in the embodiment where the flanges are made of composite material.

[0025] A further aspect of a method of producing exhaust flanges according to the invention comprises the steps of stamping metal to shape a first part of a flange; press-forming metal powder to shape a second annular sealing part of the flange; sintering the sealing part; fitting the first part onto the second part; and joining the first part and the second part to thereby bond them together and form the flange.

[0026] A still further aspect of a method of producing exhaust flanges according to the invention comprises the steps of press-forming metal powder to shape a first substantially flat part of a flange; press-forming metal powder to shape a second annular sealing part of the flange; sintering the first part and the second part; fitting the first part onto the second part; and joining the first part and the second part to thereby bond them together and form the flange.

[0027] Preferably, the materials used for making the flanges contain 0.75 to 1 weight percent of hexagonal boron nitride (BN), which enhances the corrosion resistance properties of the powder metallurgical materials used.

[0028] Furthermore, use of a composite flange assembly permits movement between the mating surfaces of the two flanges by virtue of the shape of the complementary shapes without affecting the leak-resistant properties of the exhaust flange assembly. Therefore, even if the mated flanges move with respect to each other, little or no exhaust is lost from the exhaust system during operation.

[0029] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 is a side view of an exhaust flange assembly having a first and second flange connected to ends of exhaust pipes;

Figure 2 is a sectional side view of the exhaust flange assembly of Figure 1;

Figure 3 is a side view of the flanges of the exhaust flange assembly of Figure 1 mated together;

Figure 4 is a proximal end view of the first flange;

Figure 5 is a side view of the first flange;

Figure 6 is a distal end view of the first flange;

Figure 7 is a distal end view of the second flange;

Figure 8 is a side view of the second flange;

Figure 9 is a proximal end view of the second flange;

Figure 10 is a cross-sectional view of the second flange of Figure 9 taken along line 10-10 on Figure 9;

Figure 11 is a top view of the second flange;

Figure 12 is a distal end view of a second embodiment of the first flange;

Figure 13 is a side view of the first flange of Figure 12;

Figure 14 is a proximal end view of the first flange of Figure 12;

Figure 15 is a proximal end view of another embodiment of a second flange;

Figure 16 is a side view of the second flange of Figure 15;

Figure 17 is a distal end view of the second flange of Figure 15;

Figure 18 is a proximal end view of another embodiment of a first flange for mating with the second flange of Figure 15;

Figure 19 is a side view of the first flange of Figure 18;

Figure 20 is a distal end view of the first flange of Figure 18;

Figure 21 is a side view of an exhaust flange assembly comprising the first flange of Figure 15 and the second flange of Figure 18;

Figure 22 is a side view of Figure 21 with the first and second flanges mated;

Figure 23 is a sectional side view of Figure 22;

Figure 23A is a side view of a further embodiment of an exhaust flange assembly;

Figure 23B is a side view of yet another embodiment of an exhaust flange assembly;

Figure 24 is a distal end view of another embodiment of a flange for use in an exhaust flange assembly;

Figure 25 is a cross-sectional view of the flange of Figure 24 taken along the line 25-25 of Figure 24;

Figure 26 is a side view of a further embodiment of an exhaust flange assembly;

Figure 27 is an exploded partially sectioned side view of another embodiment of an exhaust flange assembly;

Figure 28 is an exploded partially sectioned side view of yet another embodiment of an exhaust flange assembly;

Figure 29 is a sectional side view of the exhaust flange assembly of Figure 28 with the flanges mated;

Figure 30A is a side view of another embodiment of first and second flanges of an exhaust flange assembly;

Figure 30B is a sectional side view of the flanges of Figure 30A;

Figure 31A is a distal end view of another embodiment of a flange for use in an exhaust flange assembly;

Figure 31B is a cross-sectional view of the flange of Figure 31A taken along line 31B-31B of Figure 31A;

Figure 32A is a distal end view of yet another embodiment of a flange for use in an exhaust flange assembly;

Figure 32B is a cross-section view of the flange of Figure 32A taken along line 32B-32B of Figure 32A;

Figure 33 is a sectioned side view of a further embodiment of an exhaust flange assembly without the exhaust pipes;

Figure 34 is a sectioned side view of another embodiment of an exhaust flange assembly without the exhaust pipes;

Figure 35 is a sectional side view of another embodiment of an exhaust flange assembly without the exhaust pipes;

Figure 36 is a partially sectioned side view of another embodiment of an exhaust flange assembly;

Figure 37 is a sectioned side view of the gasket of Figure 36;

Figure 38 is a front view of the gasket of Figure 36;

Figure 39A is a distal view of a further embodiment of a first flange;

Figure 39B is a cross-sectional view of the first flange of Figure 39A taken along line 39B-39B of Figure 39A;

Figure 40A is a distal view of a further embodiment of a second flange;

Figure 40B is a cross-sectional view of the second flange of Figure 40A taken along line 40B-40B of Figure 40A;

Figure 41 is a sectioned side view of another embodiment of an exhaust flange assembly;

Figure 42 is a side view of the exhaust flange assembly (with exhaust pipes) of Figure 41;

Figure 43A is a front view of yet another embodiment of a first flange;

Figure 43B is a cross-sectional view of the first flange of Figure 43A taken along line 43B-43B of Figure 43A;

Figure 44A is a front view of another embodiment of a first flange;

Figure 44B is a cross-sectional side view of the first flange of Figure 44A taken along line 44B-44B of Figure 44A;

Figure 45 is an exploded side view of a further embodiment of an exhaust flange assembly without exhaust pipes;

Figure 46 is a sectioned side view of the second flange of Figure 45;

Figure 47 is a sectioned side view of another embodiment of an exhaust flange assembly;

Figure 48A is a sectioned side view of another embodiment of a first flange;

Figure 48B is a sectioned side view of the first flange of Figure 48A;

Figure 49 is a flow diagram showing a method of manufacturing a flange;

Figure 50 is a flow diagram showing a second method of manufacturing a

flange;

Figure 51 is a flow diagram showing a third method of manufacturing a flange;

Figure 52 is a flow diagram showing a fourth method of manufacturing a flange;

Figure 53 is a schematic view of an angled flange assembly;

Figure 54 is a schematic view of the flange assembly of Figure 53 with the flanges mated;

Figure 55 is a schematic view of a further angled flange assembly;

Figure 56 is a schematic view of the flange assembly of Figure 55 with the flange connected to an exhaust pipe;

Figure 57 is a schematic view of a yet another angled flange assembly;

Figure 58 is a schematic view of the flange assembly of Figure 57 with the flange connected to an exhaust pipe;

Figure 59 is a schematic view of another angled flange assembly;

Figure 60 is a schematic view of the flange assembly of Figure 59 fully assembled;

Figure 61 is a schematic view of a further angled flange assembly;

Figure 62 is a schematic view of the flange assembly of Figure 61 with the flange connected to an exhaust pipe;

Figure 63 is a schematic view of a further embodiment of an exhaust flange assembly;

Figure 64 is a schematic view of yet another embodiment of an exhaust flange assembly;

Figure 65 is a schematic view of the embodiment of Figure 64 with spacers mounted in the first flange;

Figure 66 is a schematic view of a further embodiment of an exhaust flange assembly; and

Figure 67 is a schematic view of the embodiment of Figure 66 with spacers mounted in the first flange.

DETAILED DESCRIPTION

[0031] Generally, the present invention provides an improved exhaust flange assembly for exhaust systems.

[0032] Figure 1 shows an exhaust flange assembly, or flange joint, having a first flange **1**, seen as an outer flange, and a second flange **2**, seen as an inner flange, both manufactured via a powder metallurgy process and connected to ends of exhaust pipes **3**. The outer flange **1** comprises a cavity **4** with a rounded edge **7** defined in its distal, or mating, surface while the inner flange **2** comprises an abutment comprising a generally flat distal surface **5** with a rounded edge **6** complementary to the rounded edge **7** of the cavity **4** thereby providing improved sealing characteristics, seen as a sealing seat, for the exhaust flange assembly. In the present embodiment, due to the complementary shapes of the rounded edges **6** and **7**, there is little or no path for exhaust travelling in the pipes **3** to enter into the atmosphere, which reduces or eliminates the need for a gasket in between the two flanges **1** and **2**. If a gasket is required, a less expensive gasket may be used in order to lower overall costs.

[0033] Although in this embodiment, the edges are rounded, other edge shapes for the flanges are contemplated provided they are complementary with each other. For example, the edge shape of one flange could be a sharp edge, a radius, a chamfer or a dome while the edge shape of the other flange is complementary to the selected shape.

[0034] As further shown in Figures 1, 2 and 11, the inner flange **2** has integral mounting studs **8** on opposing sides, configured to extend through corresponding holes **9** in the outer flange **1**. After the inner flange **2** is manufactured using powder metallurgy, the studs **8** are tapped to provide threads **10**. Preferably, the studs **8** comprise bolstered heads (not shown) which provide extra strength to the stud **8**. As shown in Figure 3, nuts **11** are used to tighten onto the threads **10** of the studs **8** in order to draw the outer flange **1** and the inner flange **2** together for a secure and sealed connection when the flanges are mated.

[0035] Turning to Figure 4, a proximal end view of the outer flange **1** is shown. As discussed above, the outer flange **1** comprises holes **9** which receive the studs **8** of the inner flange **2** when the flanges are mated. Preferably, the proximal surface of the outer flange **1**, the surface away from the mating surface, comprises a set of reinforcement ribs **12** which allow the overall thickness and weight of the outer flange **1** to be reduced compared to conventional flanges. Figure 5 is a side view of the outer flange **1** with the cavity **4**, the

rounded edge **7**, the holes **9** and the set of ribs **12** shown in dotted lines while Figure 6 is a distal end view of the outer flange **1** showing the cavity **4**, the holes **9** and a location **15** for the exhaust to flow from the flange to the exhaust pipe **3**.

[0036] Turning to Figures 7 to 11, more detailed schematics of the inner flange **2** are shown. Figure 7 is a distal end view of the inner flange **2** showing the studs **8** along with the rounded edge **6** of the distal surface **5**. Figure 8 is a side view of the inner flange **2** in which the rounded edge **6** may be more clearly seen along with the studs **8** with threads **10**. Figure 9 is a proximal view of the inner flange **2** showing the studs **8** connected, via a set of ribs **17**, to a location **15** for the exhaust to flow. The ribs **17** of the inner flange **2** provide similar advantages to the set of ribs **12** described with respect to the outer flange **1**. Figure 10 is a cross-sectional view taken along the line 10-10 of Figure 9 showing the inner flange **2** in more detail while Figure 11 is a top view of the inner flange **2** showing the studs **8** on opposite sides of the flange **2** along with the distal, or mating, surface **5** and rounded edge **6**.

[0037] Turning to Figures 12 to 14, a second embodiment of an outer flange **40** is shown. In this embodiment, the outer flange **40** is almost identical to the outer flange **1** with the difference being that the outer flange **40** comprises through holes **42** formed in several locations to provide weight reduction to the outer flange **40**. The through holes **42** provide similar advantages to the set of ribs **12** shown in Figure 4. The outer flange **40** also comprises a set of holes **44** for receiving studs **8** from a complementary inner flange. Although not shown, an exhaust pipe is connected to the flange **40** at the location **15** where the exhaust flows through the flange **40**. It will be understood that the inner flange may include a set of through holes instead of the set of ribs.

[0038] Figures 15 to 17 show a further embodiment of a second, or inner, flange **50** which is manufactured via a of powder metallurgy process which may be attached by press-fitting, spinning, resistance welding, crimp rolling to an end of an exhaust pipe while Figures 18 to 20 show an alternative embodiment of a first, or outer, flange **52** for mating with the inner flange **50**.

[0039] The inner flange **50** comprises a distal, or mating surface **56** with a rounded edge abutment **57** and an extension **54** arranged on the side opposite the distal surface **56**. The extension **54** has a co-axial hole, corresponding to a hole **51** in an exhaust pipe **3**, through which exhaust gases flow when the flanges of the exhaust flange assembly are mated, and in use. The extension **54** also comprises a substantially smooth inner surface and a grooved outer surface having a groove **58** surrounded by an inner ridge **60** and an

outer ridge **62**. The outer diameter of the extension **54** is preferably smaller than the inner diameter of the exhaust pipe **3** so that when the exhaust pipe **3** is attached over the extension **58**, the exhaust pipe **3** is roll-formed or spin-welded to conform to the profile of the extension defined by the groove **58**, the inner ridge **60** and the outer ridge **62**. In this manner, the exhaust pipe **3** is held securely to the inner flange **50**. This may be more clearly seen with respect to Figures 21 to 23.

[0040] The groove **58** may also have a variety of profile shapes, to accommodate fitting of the pipe either by induction heating or resistance welding and its shape is thus determined by the assembly process or method.

[0041] Furthermore, the extension **54** may be tapered, having an inner ridge **60** which is larger than the outer ridge **62** which causes the groove **58** to be optional. Pressing the exhaust pipe **3** onto the extension **54** may then be performed by using a lubricant or by inductively heating the exhaust pipe **3**.

[0042] The inner flange **50** further comprises a pair of holes **64** for receiving fastening means which secure the connection between the inner flange **50** and the outer flange **52** when the two flanges are mated. Through holes **66** are also formed in several locations to provide weight reduction to the inner flange **50**.

[0043] Turning to Figures 18 to 20, schematic views of another embodiment of the outer flange **52** are shown. The outer flange **52** comprises a cavity **68**, defined in its distal surface, with a rounded edge **70**. The distal surface **56** of the inner flange **50** nests in the cavity **68** with the rounded edge abutment **57** complementing the rounded inner edge **70** of the cavity **68** to provide a sealing seat.

[0044] The outer flange **52** further comprises a pair of holes **72** for receiving fastening means and an extension **74** arranged on a side of the flange **52** opposite the cavity **68**. Through holes **75** are formed in several locations to provide weight reduction to the outer flange **52**.

[0045] As with the inner flange **50**, the extension **74** has a co-axial hole **51**, corresponding to the hole in the outer flange **52**, through which exhaust gases flow when the flange assembly is in use and a substantially smooth inner surface and a grooved outer surface having a groove **76** surrounded by an inner ridge **78** and an outer ridge **80** with the diameter of the ridges **78** and **80** of the extension being smaller than the inner diameter of the exhaust pipe **3**. As with the inner flange **50**, when the exhaust pipe **3** is attached to the

extension **74** of the outer flange **52**, the exhaust pipe **3** is roll-formed or spin-welded over the extension to conform to the profile of the extension **74**.

[0046] Figure 21 provides a side view of an exhaust flange assembly, or flange joint, comprising the inner flange **50** and the outer flange **52**. Figures 22 and 23 are side views of the exhaust flange assembly with the inner flange **50** and outer flange **52** mated.

[0047] When the exhaust pipe **3** is attached to the inner flange **50**, a joint **55** is formed between the pipe **3** and the inner flange **50**. A similar joint **53** is formed between the exhaust pipe **3** and the outer flange **52** when they are attached. As can be seen in Figure 23, the exhaust pipe **3** is secured around the inner ridge **60** and the outer ridge **62** of the inner flange **50** to form the joint **55** and a second exhaust pipe is secured around the inner ridge **78** and the outer ridge **80** of the outer flange **52** to form the joint **53**.

[0048] When the two flanges **50** and **52** are mated, the mounting holes **64** on the inner flange **50** and the mounting holes **72** on the outer flange **52** receive fastening means, generally comprising a bolt **80** and nut **82**. A bolt **80** is inserted through each of the mounting holes **64** and **72** and a nut **82** is placed on the end of the bolt **80** and tightened onto the threads in order to draw the two flanges together and to secure the connection between the inner flange **50** and the outer flange **52**. Alternatively, one of the flanges may comprise integral mounting studs configured to extend through the mounting holes in the other flange.

[0049] Figure 23A provides a further embodiment of an exhaust flange assembly comprising an inner flange **90** and an outer flange **91**.

[0050] In this embodiment, the outer flange **91** is almost identical to the outer flange **52** with the addition of a pair of recesses **93** formed on the mating surface of the outer flange **91** having a shape generally complementary to a pair of projections **94** located on the inner flange **90** to facilitate alignment of the two flanges for mating. Advantageously, the projections **94** and the recesses **93** are arranged concentrically to the mounting holes **64** and **72** of the inner and outer flanges **90** and **91**, respectively.

[0051] Figure 23B is yet another embodiment of an exhaust flange assembly comprising further embodiments of an outer flange **95** and an inner flange **96**. In this embodiment, the outer flange **95** is identical to the outer flange **52** described above. In this embodiment, the inner flange **96** comprises recesses **97** arranged on the proximal side of the inner flange **96**. The recesses **97** have generally concave surfaces, to cooperate with bolts **80**, which preferably have heads with generally spherical lower portions to securely hold the

bolt once it has been tightened into the mounting holes **64** and **72**. Thus, the bolt **80** may swivel in the holes **64** and **72**, to facilitate alignment of the flanges when mated. Advantageously, the inner flange **96** has an increased thickness, compared to the outer flange **95**, to provide strength to compensate for the recess **97**. Furthermore, the bolts **80** have a substantially cylindrical extension **98** for the bolt head so that the extension **98** has a diameter which is larger than the diameter of the threaded portion of the bolt to prevent the bolt from sliding through the recess **97** and/or mounting hole **64**.

[0052] In an alternative embodiment, the extension **98** may be hexagonally shaped so that when the flanges are mated and the fastening means are fastened, the bolt does not spin during the tightening process.

[0053] Figures 24 and 25 show another embodiment of a flange **100**. As will be described, the flange **100** may be used as both an inner flange and an outer flange. The flange **100** comprises raised areas **102** arranged between mounting studs **104** having mounting holes **106**. The raised areas **102** provide reinforcement for the flange **100** to reduce deflection of the flange **100** when the flange **100** is securely connected to another flange **100** using fastening means such as a bolt and nut. The flange **100** has a substantially cylindrical flange extension **108**, with an inner diameter **110**, for attachment of the flange **100** to an exhaust pipe (not shown). Figure 25 is a cross-section of the flange **100** taken along the line 25-25 of Figure 24.

[0054] Figure 26 shows still a further embodiment of an exhaust flange assembly. A first flange **120**, seen as a straight flange, comprising mounting holes **122** and gasket recesses **124**, mates with a second flange **126**, seen as a curved flange, comprising mounting holes **128** and gasket recesses **130**. The curved flange **126** is substantially bowl-shaped with an outer edge **132**, bent away from the mating surface of the curved flange **126**. Thus, when fastening means in the form of mounting bolts **134** are placed through the mounting holes **122** of the straight flange **120** and the mounting holes **128** of the curved flange **126**, and a mounting nut **136** tightened onto the threads of each mounting bolt **134**, the curved flange **126** deflects towards the straight flange **120** to form a flat sealing surface which improves the sealing properties and reduces the likelihood of exhaust entering the atmosphere. This enhances the seal between the two flanges **120** and **126** and reduces further outward deflection of the curved flange **126** after the mounting nuts **136** are tightened onto the mounting bolds **134**. Although not shown, the exhaust flange assembly further comprises a gasket which is retained in the gasket recesses **124** and **130** of the flanges.

[0055] Figure 27 shows yet a further embodiment of an exhaust flange assembly. The assembly comprises a gasket element **150** arranged between a second flange **154** and a first flange **152**. The second flange **154** comprises a recess **156** with sloping side walls **158**, which generally conform in shape to a curved surface **159** of the gasket element **150** having an inner diameter **160**. The second flange **154** also comprises mounting holes **162**. Similarly, the first flange **152** comprises a recess **164** with sloped side walls **166**, which generally conform in shape to the curved surface **159** of the gasket element **150** having an inner diameter **168**. The first flange **152** also comprises mounting holes **170**.

[0056] The gasket element **150** has an inner diameter **172**, substantially the same as inner diameters **160** and **168** and further comprises a flange gap defining protrusion **174** arranged along its circumference. When fastening means, in the form of mounting bolts **176**, are inserted into the mounting holes **162** and **170** of the second and first flanges **154** and **152**, respectively, and a mounting nut **178** is tightened onto each mounting bolt **176**, the two flanges **152** and **154** are drawn together and compress the gasket element **150**, which reduces the amount of amount of float (relative movement of the flanges) to provide an enhanced leak resistance and therefore improved sealing characteristics for the exhaust flange assembly. Also, the complementary shape of the mating surface of the flanges allows for the flanges to move with respect to each other however, retaining their sealing properties. In operation, the exhaust flows from the exhaust pipe through the inner diameters of the flange assembly to an exhaust pipe at the other end of the assembly.

[0057] Figures 28 and 29 show a further embodiment of an exhaust flange assembly comprising a composite gasket element **200** arranged between a second flange **204** and a first flange **202**. The first flange **202** is identical to the first flange **152** of Figure 27 while the second flange **204** comprises mounting holes **206** and a substantially cylindrical flange extension **208** for attachment to an exhaust pipe (not shown). Further, the second flange **204** has a backing plate portion **210** arranged on the same side of the flange as the flange extension **208**. The backing plate portion **210** has an inner diameter **212** and an inner surface **214**, facing away from the flange extension side of the flange **204**. The inner surface **214** of the flange **204** is larger than the inner diameter **212** of the backing plate portion **210**. The composite gasket element **200** has a curved surface **218**, generally conforming in shape to the recess **164** and the sloping side walls **166** of the first flange **202** and has an inner diameter **220**, substantially the same as the inner diameters **168** and **212** of the first and second flanges **202** and **204**, respectively. The gasket element **200** further comprises an

outer surface **222** and a substantially flat surface facing the second flange **204**. When mounting bolts (not shown) are inserted into the mounting holes **206** and **170**, and a mounting nut (not shown) is tightened onto each mounting bolt, the two flanges compress the gasket element **200** to provide an enhanced leak resistance for the flange assembly. The backing plate portion **210** retains the composite seal between the second flange **204** and the composite gasket element **200**. Figure 29 shows the second flange **204** and the first flange **202** mated with the gasket **200** there between. In operation, the exhaust flows from the exhaust pipe through the inner diameters of the flange assembly to an exhaust pipe at the other end of the assembly.

[0058] Figures 30A and 30B show a further embodiment of an exhaust flange assembly similar to the embodiments shown in Figures 27 to 29. A composite gasket element **220** is bonded to a second flange **222**, seen as an inner flange, by pressing and sintering the gasket element **220** and the flange **222** in one sintering step, or by sintering the inner flange **222** first then inserting the pressed gasket element **220** and sintering again. The composite gasket element **220** is arranged between a first, or outer, flange **224** (similar to the first flange **152** as described in Figure 27) and the inner flange **222**. The inner flange **222** has mounting holes **226** and a backing plate portion **228** arranged on the side of the flange away from the gasket **220**. The backing plate portion **228** has an inner diameter **230** and an inner surface **232** facing away from the backing plate portion **228**. The inner flange **222** has a general inner diameter **234**, which is larger than the inner diameter **230** of the backing plate portion **228**.

[0059] The composite gasket element **220** has a curved surface **236**, generally conforming in shape to the recess **164** and sloping side walls **166** of the first flange **224**. The composite gasket element **220** further comprises an inner diameter **238**, substantially the same as the inner diameters **230** and **168** through which the exhaust flows.

[0060] Figures 31A and 31B show yet another embodiment of a unisex flange **250** which may be used as both the first and second flanges of an exhaust flange assembly. The flange **250** comprises an annular gasket recess **252**, which has an inner wall **254** and an outer wall **256**. Further, the flange **250** has mounting holes **258**, and an inner diameter **260**. The inner wall **254** and the outer wall **256** form at least one squeeze area **262**, where the width of the gasket recess (the distance between the outer wall and the inner wall) is substantially narrower than a maximum gasket recess width (substantially equal to the diameter of the inner wall **254**). In this manner, the gasket is formed to fit within the groove

with the four pressure points, squeeze areas, providing the pressure to retain the gasket. In other words, the generally circular gasket is stretched to fit over the substantially oval gasket recess **252** whereby the stretching of the gasket creates squeeze areas in its circumference which serve as pressure points for retaining the gasket on the gasket recess. The gasket (not shown) is also held in the gasket recess **252** after being inserted. Preferably, two such squeeze areas **262** are defined in the gasket recess **252**. Figure 31B is a cross-sectional view taken along the line 31B-31B of Figure 31A.

[0061] Figures 32A and 32B show an alternative embodiment of a unisex flange **300** having an annular gasket recess **302** comprising an inner wall **304** and an outer wall **306** with the inner wall having an inner diameter **310**. At least one protrusion **312** is arranged along the inner wall **304** or the outer wall **306** to form at least one squeeze area **314**, where the width of the gasket recess is substantially narrower than a maximum gasket recess width so that the gasket is held in the gasket recess after insertion. Preferably, multiple squeeze areas **314** are defined in the gasket recess **302** by multiple protrusions **312** on the inner wall **304**. The flange **300** further comprises mounting holes 308. Figure 32B is a cross-sectional view taken along the line 32B-32B of Figure 32A.

[0062] Figure 33 shows a further embodiment of an exhaust flange assembly similar to the embodiment shown in Figures 30A and 30B. The exhaust flange assembly comprises a first flange **320** and a second flange **322**. The first flange **320** is similar to the first flange **152** described with respect to Figure 27 while the second flange **322** has mounting holes **326** and a backing plate portion **328** arranged on the side of the flange opposite the gasket **324**. The backing plate portion **328** has an inner diameter **330** and an inner surface **332**, facing away from the flange gasket **324**. The first flange **320** has a general inner diameter **334**, which is larger than the inner diameter **330** of the backing plate portion **328**. A composite gasket element **324** is bonded to the second flange **322**. The composite gasket element **324** is located between the first flange **320** and the second flange **322**. The composite gasket element **324** has a curved surface **336**, generally conforming in shape to the recess **164** and sloping side walls **166** of the first flange **320**. The composite gasket element has an inner diameter **338**, substantially the same as the inner diameters **330** and **168**. Additionally, the composite gasket element **324** has a gasket recess **340** arranged on the curved surface **336**, to receive an additional annular sealing gasket (not shown).

[0063] Figure 34 shows still a further embodiment of an exhaust flange assembly similar to the embodiment shown in Figure 33. The first flange **320** of Figure 34 is the same

as the first flange **320** of Figure 33. A second flange **342** comprises an inner diameter **344**, mounting holes **346** and a protrusion **348**. The protrusion **348** has a curved surface **350** which cooperates with the first flange **320** in that it generally conforms in shape to the recess **164** of the first flange **320**. Additionally, the protrusion **348** has a gasket recess **352** arranged on the curved surface **350**, to receive an additional annular sealing gasket (not shown).

[0064] Figure 35 shows yet a further embodiment of an exhaust flange assembly comprising a second flange, seen as an inner flange, **370** with an exhaust mounting extension **372**, mounting holes **374**, gasket recesses **376** and a sealing extension **378.** A first flange, seen as an outer flange, **380** has an exhaust mounting extension **382**, mounting holes **384**, gasket recesses **386** and a sealing recess **388** having an outer diameter **390** substantially corresponding to the outer diameter of the sealing extension **378**. The sealing extension **378** and the sealing recess **388** thus cooperate to provide a seal when the flanges are mated as well as enhanced alignment assistant between the two flanges. The flanges are fastened together using fastening means comprising bolts **392** and nuts **394** with a gasket located between the two flanges. The sealing extension **378** adds rigidity to the flange joint and maintains pipe alignment when the flanges are mated. Exhaust pipes are connected to the mounting extensions **372** and **382** using a roll-forming process as described above.

[0065] Figures 36 shows yet a further embodiment of an exhaust flange assembly. The assembly comprises a second flange **400**, seen as an inner flange, comprising an exhaust mounting extension **402**, mounting holes **404** and an annular gasket holding ridge **406** with a base **408** and a first flange **410**, seen as an outer flange, comprises an exhaust mounting extension **412**, mounting holes **414** and an annular gasket holding recess **416** with an annular ring **418**. The gasket holding ridge **406** and the gasket holding recess **416** thus cooperate to positively hold a shaped gasket **420** to provide a positive seal and enhanced alignment between the two flanges **400** and **410**. The flanges **400** and **410** are fastened together using fastening means such as bolts **422** and nuts **424**.

[0066] Figures 37 and 38 provide detailed schematic views of the shaped gasket **420**. The gasket **420** comprises a gasket inner diameter **426**, which is substantially the same or larger than the inner diameters of the exhaust openings of the flanges. The gasket holding ridges **416** mate with a gasket ridge holder **428** while the other end of the gasket ridge holder **428** rests in the gasket holding recess. The gasket ridge holder **428** comprises

an edge **430**. The gasket has five sealing surfaces on its "hat"-like cross-section (brim, side, top, other side and other brim), and this shape gives no direct escape for gases. The gasket is made of a resilient material, and preferably laminated and/or spirally wound.

[0067] Figures 39A to 42 show a further embodiment of a flange joint. Figures 39A and 39B are schematics of an outer flange **450** comprising a conical rib **452** on a sealing surface **454** of the outer flange **450** which cooperates with a conical recess **464** of an inner flange **453** (as shown in Figure 40A and 40B). The outer flange **450** further comprises a pipe attachment surface **456** having a pipe attachment means **458**. An exhaust through hole **460** is arranged in the outer flange **450** for passage of exhaust gas when the flange is assembled as part of the exhaust system flange joint. Mounting holes **462** are also arranged through the outer flange **450**.

[0068] The inner flange **453** comprises a conical recess **464** on a sealing surface **466** of the inner flange **453**. The inner flange **453** further has a pipe attachment surface **468** having a pipe attachment means **470**. An exhaust through hole **472** is arranged in the inner flange **453**, for passage of exhaust gas when the flange **453** is assembled as part of an exhaust system flange joint. Mounting holes **474** are also arranged through the outer flange. Figure 41 shows an exhaust flange assembly comprising the mating of the outer flange **450** and the inner flange **453** while Figure 42 shows the exhaust flange assembly of Figure 41, with the outer flange **450** and the inner flange **453** joined to respective pipes **478** with connecting bolts **480** and nuts **482** used to draw the two flanges together. When the inner and the outer flanges **453** and **450**, respectively, are fastened together, the conical rib **452** and the conical recess **466** form a compression fitting to eliminate leaks in the flange joint. The rigidity of the joint is also enhanced by the compression fitting of the invention.

[0069] Figures 43A and 43B show a further embodiment of a second flange, or inner flange, while Figures 44A and 44B show yet another embodiment of an inner flange.

[0070] In Figures 43A and 43B, the inner flange **500** mates with an outer flange **502** which is identical to the outer flange **370** of Figure 33. The inner flange **500** is manufactured in two parts and comprises a flat part (backing plate) which has mounting holes **504**, a central through hole **506**, a recess **508** with an end wall **510** and a sealing part **512**. The flange material is preferably sintered material, possibly different material in the two different parts, for instance using material with enhanced sealing properties for the sealing part and material with enhanced strength for the backing plate. The sealing part **512** has an outwardly curved surface **514** generally corresponding to the recess **516** with sloping side

walls **518** of the outer flange **502**. The sealing part further has a recess **520** having an inner annular surface **522**. The sealing part **512** also has an outer annular sealing surface **524**. The sealing part **512** further has an inner diameter **526**, smaller than the inner diameters (central through hole) **506** and **528**, respectively, of the inner flange and the outer flange. The two parts of the inner flange **500** are made in separate pressing operations and assembled and bonded in a sintering process. The required press force is lower, making it possible to use smaller and cheaper presses. Both parts are optionally pre-sintered at relatively low temperatures and then pressed together and subjected to a final sintering step, during which the two parts bond together. When the two parts are pressed together, the inner flange recess **508** contacts the sealing part recess **520**, and the inner flange recess end wall **510** contacts the outer annular sealing surface **524**, whilst the sealing part inner annular surface **522** contacts the surface of the central through hole **506**, forming mating surfaces for the two parts. Thus, the inner flange recess has a shape cooperating with and corresponding to the shape of the sealing part recess. For the two-piece inner flange described above, a bonding agent/welding flux may be applied to the mating surfaces after an optional pre-sintering step but before final sintering, to enhance the bond between the two parts after sintering. Further, an optional weld may be applied to the inner flange after sintering, to additionally strengthen the joint between the sealing part and the backing plate. The weld would be applied on the side of the inner flange where the sealing part extends from the backing plate, and either be in the form of a tack weld or a continuous weld along the full joint between the sealing part and the backing plate.

[0071] As is shown in Figures 43A and 43B, the inner flange **500** may have two mounting holes **504** and a single step recess **508**, as described above.

[0072] An alternative embodiment of an inner flange **530** is shown in Figures 44A and 44B. The inner flange **530** has three mounting holes **532** and a multi-stepped recess **534** corresponding in shape to a multi-stepped recess of the sealing part (not shown). The larger number of mounting holes makes a secure attachment of the inner flange and a outer flange easier, and the multi-stepped recess enlarges the surface area between the two parts of the inner flange, which enhances the bonding between the two parts after final sintering. The inner flange **530** further comprises a centre through hole **536**. It will be understood that the inner flange **530** may also be used in the exhaust flange assembly of Figure 45.

[0073] Turning to Figure 47, an exhaust flange assembly, similar to the exhaust flange assembly described with respect to Figure 42 is shown. The outer flange **453** is

identical to the outer flange **453** described in Figure 42 while the inner flange **450** includes a pair of integral stand-offs **540** which receive the fastening means **480** and provide support to the fastening means.

[0074] As is shown in Figures 48A and 48B, an outer flange **550** may be of two-piece construction (as outlined in Figures 43A to 46). The outer flange **550** comprises a flat part (backing plate) which has mounting holes **552**, a central through hole **554** and a recess **556** with an end wall **558**, and a sealing part **560**. The flange material is preferably sintered material, possibly different material in the two different parts, for instance using material with enhanced sealing properties for the sealing part and material with enhanced strength for the backing plate. The sealing part **560** has an inwardly curved surface **562**. The sealing part further has a recess **564** having an inner annular surface **566** and an outer annular surface **568**. The sealing part **560** further has an inner diameter **570**, smaller than the central through hole **554**. The two parts of the outer flange **550** are made in separate pressing operations of a sintering manufacturing process. The required press force is lower, making it possible to use smaller and cheaper presses. Both parts are optionally pre-sintered at relatively low temperatures and then pressed together and subjected to a final sintering step, during which the two parts bond together. When the two parts are pressed together, the outer flange recess **556** contacts the sealing part recess **564**, and the outer flange recess end wall **558** contacts the outer annular sealing surface **568**, whilst the sealing part inner annular surface **566** contacts the surface of the central through hole **554**, forming mating surfaces for the two parts. Thus, the outer flange recess has a shape cooperating with and corresponding to the shape of the sealing part recess. For the two-piece outer flange described above, a bonding agent/welding flux may be applied to the mating surfaces after an optional pre-sintering step but before final sintering, to enhance the bond between the two parts after sintering. Further, an optional weld may be applied to the outer flange after sintering, to additionally strengthen the joint between the sealing part and the backing plate. The weld would be applied on the side of the outer flange where the sealing part extends from the backing plate, and either be in the form of a tack weld or a continuous weld along the full joint between the sealing part and the backing plate.

[0075] Turning to Figures 49 to 52, flow charts outlining methods of manufacturing the various embodiments of the flanges are shown. In the method of Figure 49, the back plate of the flange is manufactured using a stamping process (step **600**) while the sealing part (the recess or the rounded edge) of the flange is manufactured using a powder

metallurgy process (step **602**). After the sealing part of the flange is manufactured, the sealing part is pre-sintered (step **604**). The sealing part and the back plate are then placed in contact and sintered together (step **606**) and assembled as a flange (step **608**).

[0076] In the method of Figure 50, the back plate is manufactured using a stamping process (step **610**) while the sealing part is manufactured using a powder metallurgy process (step **612**) and then sintered (step **614**). After the sealing part is sintered, the back plate and the sealing part are assembled (step **616**) and then welded or bonded together to form the flange (step **618**).

[0077] In the method of Figure 51, the back plate and the sealing part are both manufactured using a powder metallurgy process (steps **620** and **622**) and then pre-sintered (steps **624** and **626**). After being pre-sintered, both the back plate and the sealing part are assembled together (step **628**) and then sintered together to form the flange (step **630**).

[0078] In the method of Figure 52, both the back plate and the sealing part are manufactured via a powder metallurgy process (steps **632** and **634**), assembled (step **636**) **and** then placed in contact and sintered together to form the flange (step **637**).

[0079] During the manufacture of the sealing part via a powder metallurgy process, the material of the sealing part may be selected to minimize the co-efficient of expansion to reduce the wear on a gasket if a gasket is required.

[0080] Figures 53 to 62 provide yet further embodiments of exhaust flange assemblies in which an angled flange assembly is provided whereby the angle is between a longitudinal direction of an exhaust pipe and the flange itself.

[0081] In the embodiment shown in Figures 53 and 54, the flange assembly **640** comprises a first flange **642** and a second flange **644**. Both of the flanges **642** and **644** comprise a substantially flat edge **646** (having a recess **648**) and a spherical end **650**. Each recess **640** is shaped to receive one end **652** of an angled exhaust pipe **654**. The ends **652** of the angled exhaust pipe **654** are generally connected to the recesses **640** of the flanges **642** and **644** by welding, brazing or other known bonding processes to manufacture a flange assembly having a pre-determined angle between the mounting faces of the flanges. Figure 54 shows a flange assembly with the flanges connected to the angled exhaust pipe.

[0082] Turning to Figures 55 and 56, another flange assembly **660** comprising a flange **662** having a flat edge **664** with a recess **666** and a spherical edge **668** is shown. The recess **666** is frusto-conical, seen as a truncated cone, allowing an exhaust pipe **670** with an

angled end, i.e. the end is not perpendicular to a longitudinal direction of the pipe, to be inserted and fastened to the flange **662**. A shoulder **672** is arranged on the pipe **670** so that, after the pipe **670** has been fastened to the flange **662**, there is little or no gap between the flange **662** and the pipe **670** so that exhaust does not leak from the flange assembly during use.

[0083] Turning to Figures 57 and 58, yet a further angled flange assembly is shown. The flange assembly **672** comprises a flange **674** having a flat edge **676** with a recess **678** and a spherical edge **680** is shown. In this embodiment, the flange **672** is angled with the recess **678** adapted to receive an end **682** of the exhaust pipe **684**. The angle in the flange **674** is provided so that non-linear connections may be achieved in the exhaust system. The pipe **684** is fastened to the flange **674** by a method such as welding.

[0084] Turning to Figures 59 and 60, another angled flange assembly **686** is shown comprising a flange **688** comprising a flat edge **690** having a recess **692** and a spherical edge **694** is shown. The flange assembly **686** further comprises an angled portion **696**. Both the flange **688** and the angled portion **696** are advantageously manufactured via a powder metallurgy process and are sintered together after optional pre-sintering steps. The desired angle of the flange assembly is thus provided by the angled portion **696**. An exhaust pipe **698** is fastened to the angled portion **696** either by welding or brazing. Alternatively, the pipe **698** may be inserted in a recess in the angled portion **696** (not shown).

[0085] Turning to Figures 61 and 62, an angled flange assembly **700** comprising a flange **702** having a mating edge **704** with a recess **706** for receiving a an exhaust pipe **708** having a shoulder **710** is shown. The exhaust pipe is attached to the flange via press-fitting, spinning, resistance welding, crimp rolling or other known processes.

[0086] Turning to Figure 63, a further embodiment of an exhaust flange assembly in accordance with the present invention is shown. The flange assembly **712** comprises a first flange **714** formed with a pair of integral spacers **716** using a powder metallurgical process and a second flange **718**. The first flange **714** further comprises a pair of holes **719** for receiving fastening means, in the form of bolts **720,** which assist in securing the connection between the flanges **714** and **718** when they are mated. The bolts **720** are secured by individual nuts **722**. The spacers assist in aligning the two flanges when they are to be mated.

[0087] The first flange **714** further comprises a recess **724** for receiving a complementary shaped abutment **726** located on the surface of the second flange **718** to assist in the mating process to align the flanges **714** and **718**.

[0088] Turning to Figures 64 and 65, another embodiment of a flange assembly is shown. In this embodiment, the flange assembly **730** includes a first flange **732** comprising a pair of spacer recesses **734** connected to mounting holes **735** for receiving fastening means, in the form of a bolt **734**, and a recess **736** for receiving a complementary shaped abutment **738** on a second flange **740**. Spacers **742**, preferably manufactured using a pressing process, are inserted into the pair of spacer recesses **734** and fastened to the first flange **732** via sintering. After the bolts **732** are inserted into the spacer recesses **734** and the spacers **742**, nuts **744** are used to secure the connection between the two flanges by tightening them on the bolts.

[0089] Alternatively, as shown in Figures 66 and 67, the spacers **746** may be aligned with the mounting holes **748** and held in place during the sintering process.

[0090] In the embodiments shown in Figures 64 to 67, a brazing alloy may advantageously be used between the spacer and the first flange to improve the bonding between the two parts. Furthermore, the spacers and/or the flange may be pre-sintered and assembled before the final sintering process.

[0091] Advantageously, the present invention overcomes some of the problems in prior art exhaust flange assemblies. Firstly, by using a powder metallurgy process to manufacture the flanges, more complex flange shapes may be achieved. Also, the powder metallurgy process is also less expensive than some of the methods in the prior art.

[0092] Moreover, the embodiments of the present invention also reduces or eliminates the amount of exhaust which escapes into the atmosphere by providing mating surfaces on the flanges which are complementary to each other. This also assists in providing alignment to the flanges. Also, the use of spacers allows for further alignment of the flanges. Use of ribs or through holes also allows for a flange that is lighter than some prior art flanges.

[0093] When gaskets are required, the mating surfaces of the flanges assist in retaining the gaskets so that they do not fall out during assembly of the exhaust flange assembly. This may also be assisted by integral fastening means which are manufactured

as part of the flange so that there is less opportunity for the fastening means to slip out during assembly.

[0094] The invention provides a number of advantages, which include that the use of powdered metal permits reduced thickness and weight by permitting the use of reinforcing ribs or the formed tightening holes, that the sealing configuration avoids a direct escape path for exhaust gases, thereby potentially reducing the need for gaskets and potentially reducing emissions and to facilitate the alignment of the different parts of the exhaust system.

[0095] Preferably, the outer flange is made of one material and the inner flange is made of another material. In this way, the heat expansion of the flange can be regulated to compensate for differences in heating of the flanges (the flange closest to the engine will theoretically be heated more than the flange further away). By choosing a material having a lower heat expansion for the flange closest to the engine, and a material having a higher heat expansion for the other flange, both flanges can be made to expand equally much during use, thus enhancing the fit and seal of the flange assembly.

[0096] Preferably, the materials used for making the flanges contain between 0.75 to 1 weight percent of hexagonal boron nitride (BN), which enhances the corrosion resistance properties of the powder metallurgical materials used, as disclosed in US 6,103,185.

[0097] Using flanges as described in the different embodiments of the invention will enhance the sealing and rigidity properties of the flange joint, compared to known flange assemblies.

[0098] The invention provides a number of advantages such as the inclusion of integral mounting studs avoid the need for separate studs, that the use of powdered metal permits reduced thickness and weight by permitting the use of reinforcing ribs and that the sealing configuration avoids a direct escape path for exhaust gases, thereby potentially reducing the need for gaskets and potentially reducing emissions.

[0099] Furthermore, when assembling exhaust pipes it might be economical to use standard length bolts, which might be too long for the application and possibly interfere with the pipe if it has a sharp bend adjacent the flange. To accommodate longer bolts, it is foreseen to produce the sintered flanges having a stand-off sleeve integrally formed on the surface of the flange which faces away from the sealing surface of the flange, as shown in Figure 47. When using a two-piece flange, having a separate sealing part, the two parts may be fixed to each other by low-strength glue, or similar, to secure the sealing part in place until

the flange is used with another flange to form a flange assembly. After the flanges are joined, the sealing part will be held in place by the joining forces.

[00100] As will be understood, although not expressly shown in each figure, it will be understood that each of the flanges comprises means for attaching to an exhaust pipe.

[00101] The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.